Cloud Climate Applications for the AVHRR Record

Michael J Foster[1]; Andrew Heidinger[2]

[1]Cooperative Institute for Meteorological Satellite Studies, Space Science and Engineering Center, University of Wisconsin-Madison
[2]Office of Research and Applications, NOAA / NESDIS, Madison, WI, USA

Mean Liquid Water Path

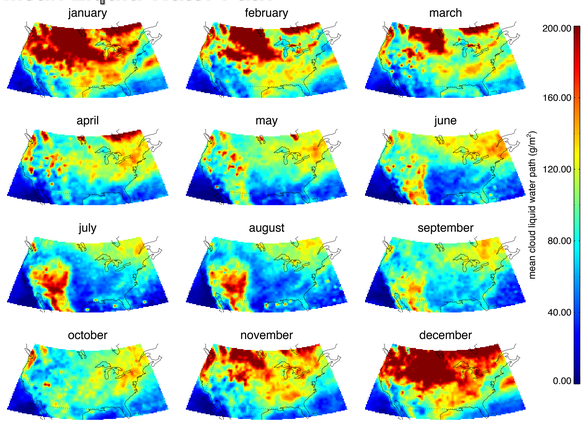

Figure 1. North American monthly mean liquid water path taken from PATMOS-x/AVHRR (1981-2012). Values are calculated for 1.0 degree boxes using cloud optical thickness and particle effective radius.

Liquid Water Path Uncertainty

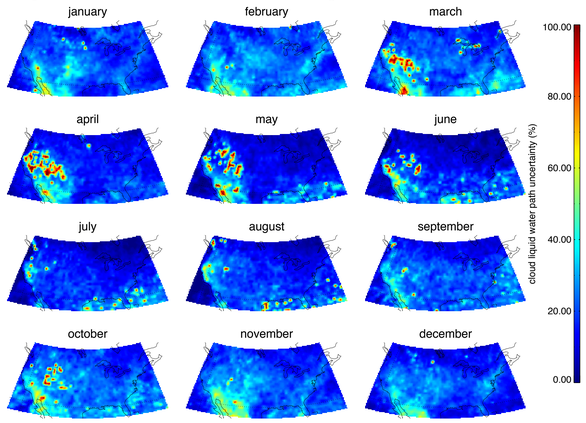

Figure 2. PATMOS-x/AVHRR (1981-2012) monthly liquid water path uncertainty estimates. Values calculated for 1.0 degree boxes. Units are percent difference from the mean.

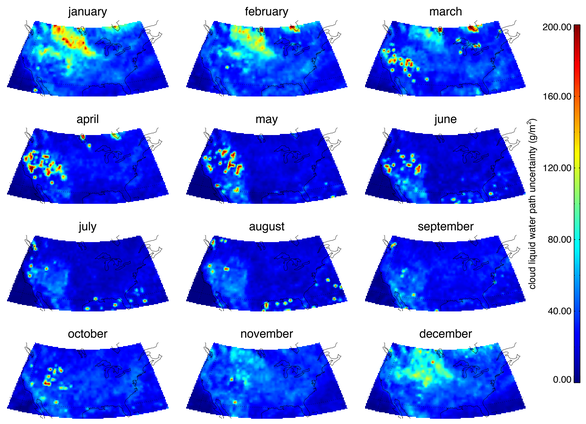

Figure 3. Same as Figure 2 but the units are in g/m².

Abstract

NOAA's Advanced Very High Resolution Radiometer (AVHRR) record begins in 1978 and represents over three decades of continuous cloud measurements. The Pathfinder Atmospheres Extended (PATMOS-x) team processes this record using consistent algorithms and inter-sensor calibrated radiances, making the data set suitable for climate monitoring and assessment of extreme environmental events. Identifying statistically significant trends in cloud amount or its properties requires the additional step of quantification and aggregation of various sources of uncertainty.

In this study we quantify uncertainty in the PATMOS-x AVHRR record from multiple sources such as the naïve Bayesian cloud masking algorithm, sensor calibration, satellite drift, viewing geometry and synoptic and seasonal variability. These diverse, and often correlated, sources are aggregated into a single estimate of uncertainty, from which an analysis of long-term changes in cloudiness and cloud optical properties over North America is performed.

Liquid Anomaly Histograms

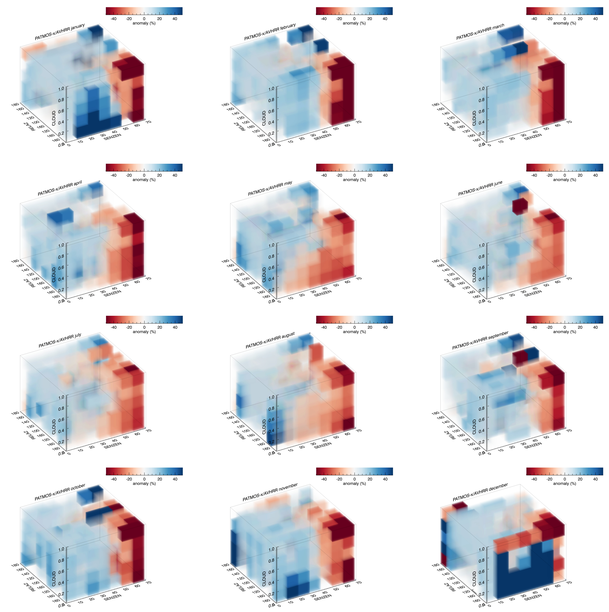

Figure 4. North American monthly liquid water path 3-dimensional histograms using sensor zenith angle, relative azimuth angle and cloud fraction as the bin parameters. The units are percent difference from the mean liquid water path (normalized separately for each cloud fraction bin). These histograms represent the average of those created for each 1.0 degree box.

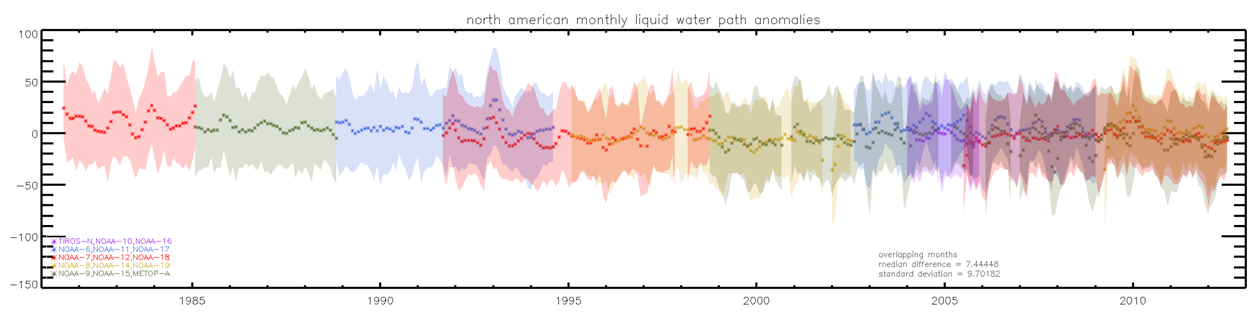

Figure 6. Time series of PATMOS-x/AVHRR monthly liquid water path anomalies over North America. Shading represents uncertainty estimates, calculated using the methods described above. Monthly averages have been removed to account for seasonal effects. The median and standard deviation for all pairs of overlapping satellite months are located in the bottom right corner. For months with more than two satellites available all pairing combinations are included.

Methodology

The method we have adopted to identify and aggregate several, oft-correlated sources of uncertainty is to generate normalized monthly anomaly histograms. These histograms can in turn be used to estimate bias based on the location, time of year, cloud homogeneity and viewing geometry of individual measurements. A distribution of these biases, accumulated over time and space, are used to create monthly estimations of uncertainty. The parameters used to generate these histogram include:

- Relative Azimuth Angle
- Sensor Zenith Angle
- Cloud Fraction

The histograms shown here have been created using the PATMOS-x/AVHRR record over much of North America (1981-2012). The cloud fraction parameter is used as a proxy for cloud homogeneity. To account for seasonal and geographic variations, the histograms are created for 1.0 degree boxes for each month. Furthermore ice clouds and water clouds are considered separately.

Ice Anomaly Histograms

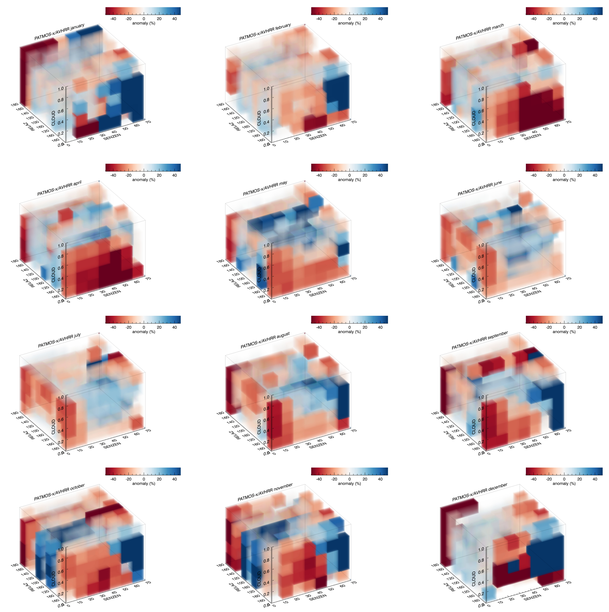

Figure 5. Same as Figure 4 but for ice water path.

Mean Ice Water Path

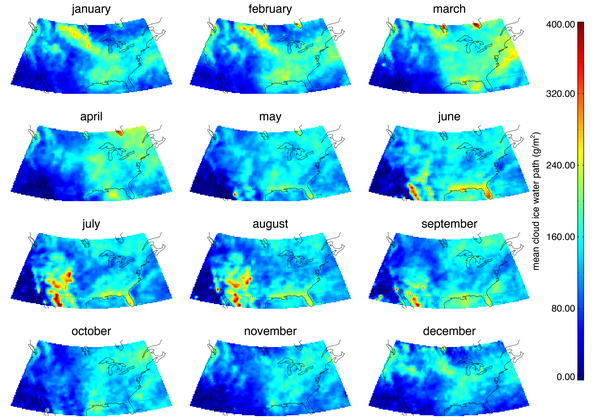

Figure 7. North American monthly mean ice water path taken from PATMOS-x/AVHRR (1981-2012). Values are calculated for 1.0 degree boxes using cloud optical thickness and particle effective radius.

Ice Water Path Uncertainty

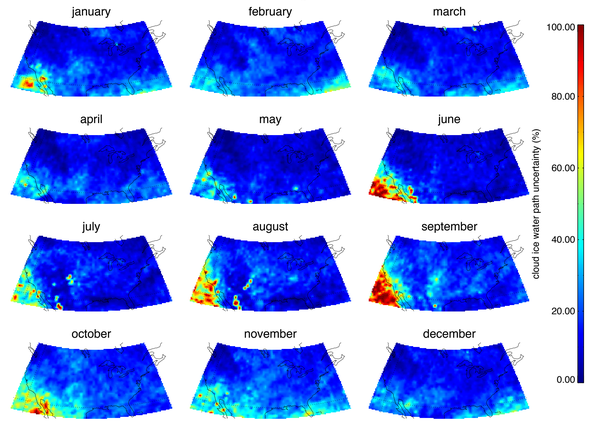

Figure 8. PATMOS-x/AVHRR (1981-2012) monthly ice water path uncertainty estimates. Values calculated for 1.0 degree boxes. Units are percent difference from the mean.

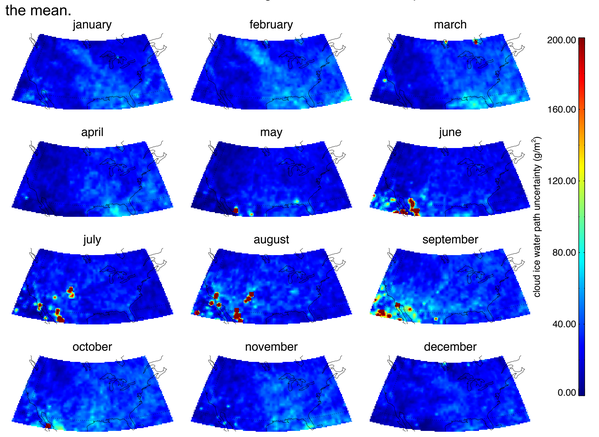

Figure 9. Same as Figure 8 but the units are in g/m².